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ABSTRACT

The techniques, procedures, and principal findings of 15 different experiments in a research program on interactive communication are summarized in this paper. Among the principal findings reported are that: problems are solved faster in communication modes that have a voice channel than in those that do not have a voice channel, modes of communication that have a voice channel are much wordier than those that do not have a voice channel, the wordiness of voice modes of communication appears to be due to the fact that it is so easy to talk rather than to the lack of a hard copy to which one can refer at will, and for none of the many problems tested is there any significant advantage of face-to-face communication over communication by voice alone. Other findings reported in the paper relate to communication by persons of diverse abilities, the effect of interrupt capability on communication, the unruliness of natural communication, and the use of restricted vocabularies for communication purposes. (Author/FL)

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# INTERACTIVE COMMUNICATION:

## A Few Research Answers for a Technological Explosion

Text of an invited address given at
the Eighty-sixth Annual Convention of the
American Psychological Association
Toronto, Ontario, Canada

31 August 1978

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I should also like to express my gratitude to my colleagues, students, and former students without whose dedicated, loyal, and enthusiastic support I could not possibly have carried on this program. They are, in alphabetical order: Drs. Michael J. Kelly, Gerald P. Krueger, Robert B. Ochsman, Charles M. Overbey, Robert N. Parrish, François C. Stoll, Gerald D. Weeks, and Ederyn Williams; Messrs. Mark A. Brecht, W. Randolph Ford, Douglas G. Hoecker, Paul R. Michaelis, and Peter D. Pagerey; and Ms. Joan M. Roemer.

On July 31, 1971, and at various times during the following two days, millions of people settled comfortably in front of their television sets to watch two astronauts, David R. Scott and James B. Irwin, walk and drive around on the cold, bleak, airless surface of the moon. From time to time two television cameras on the moon, one near the landing capsule and one mounted on the lunar roving vehicle, moved and refocused in response to commands from Mission Control in Houston, Texas, nearly half a million kilometers away. Meanwhile, television viewers on earth listened to jokes, bits of information, instructions, and questions and answers between the astronauts and Mission Control.

Although the technology that made these telecommunications possible was largely developed during the lifetimes of many people alive today, one of the most remarkable things about them was that they were accepted pretty much as an ordinary occurrence by the millions of people who saw them. While the first commercial radio broadcasts were made from Station KDKA as early as 1920, and the first commercial television broadcasts by the National Broadcasting System in 1939, most of the communications technology that we now accept so matter of factly has been developed only within the 30 or so years since World War II. Indeed, the rapidity with which technological developments have followed one another during the past few decades represent a true communication explosion.

The systems that have been the end products of this technology have not all been success stories. Some in fact have been colossal failures, largely due to the way people interact with or respond to these systems. This state of affairs has led some people to conclude that advances in modern technology have surpassed our understanding of their human consequences and of the ways these new systems need to be designed to match human needs, capacities, and limitations.

In my talk today, I would like to describe briefly some of the findings that have come out of a program of research at The Johns Hopkins University on human factors in telecommunication and teleconferencing systems. That may all sound very applied and more like engineering than psychology; but the research that I shall describe is basic psychological research, despite its applied origin. As you will see, our work relates to such conventional topics in psychology as person-to-person communication, problem solving, psycholinguistics, and group behavior. More

important, perhaps, is that the applied origins of our work have led us to ask basic questions about human behavior that have not been asked in the past and that probably would never have otherwise occurred to people to ask.

Altogether my colleagues, my students and I have completed 15 separate experiments and have published 21 articles and theses based on those experiments. A list of our publications is at the end of this paper. Several other articles are in various stages of preparation. The richness of our findings makes it impossible for me to cover them all; instead, I shall try to extract some of the most interesting findings and integrate them into a series of broader generalizations. To emphasize the generality of our conclusions, I shall sometimes show how the same findings come up repeatedly in study after study even when studies are performed by different experimenters, under different conditions, and with different subjects.

In confining myself to the Hopkins research program, I don't mean to suggest that it's the only one that has been concerned with these problems. A great deal of very good work on person-to-person communications, and on human factors in telecommunications, has been done in other laboratories. While acknowledging the fine work of those other laboratories, I have chosen to confine myself to my own program for two largely selfish reasons: (a) this is the first opportunity I've had to summarize and to present our findings to an audience such as this one, (b) my research program has some rather unique features that are not duplicated in any other program that I know about.

## Goals of the Hopkins Program

The goals of the Hopkins program are to discover

- how people naturally communicate with each other when they are required to solve problems of various kinds,
- how interactive human communication is affected by the machine devices and systems through which people converse,
- what significant system and human variables affect interactive communication.

## Interactive versus Unidirectional Communication

In communication research, it's important to make a distinction between interactive and unidirectional communication. For years psychologists and other scientists have been concerned with the effectiveness of unidirectional modes of communication, such as highway signs, books, lectures, and television broadcasts. In unidirectional communication,

the person to whom the message is addressed is a passive recipient of the information. Nothing that he does or says affects the communicator, the communication process, or the content of a message. In interactive communication, by contrast, the participants are both senders and receivers of information. As a result, communicators, the communication process, and the contents of messages can be, and usually are, affected by all the participants. Conferences, seminars, telephone conversations, arguments, and even man-computer dialogues are examples of interactive communication. In my talk today, I shall be entirely concerned with interactive communication.

## Areas of Application

All the research conducted in the Hopkins program has been done by having people communicate with one another in various ways. Since the findings originate from basic laboratory research, they are, we believe, relevant to several areas of application. Foremost among these areas of application is the design and use of telecommunication and teleconferencing systems. The findings are also relevant to interactive man-computer systems and to the conduct of face-to-face meetings or conferences. The purpose of the Hopkins program, however, has been to produce basic data about human interactive communication and not to concern itself directly with specific areas of application.

## The Ways People Can Naturally Communicate

In considering modes of communication, it is interesting to ask first what human skills are used naturally in person-to-person communication. The list is surprisingly short. Everyone, even the inarticulate and dumb, can convey information by body movements--postures, gestures, and facial expressions. Virtually everyone can speak one of the natural languages--perhaps not grammatically, but fluently. A majority of people have at least some elementary level of competence in writing. Finally, a respectable number of people know how to type and even some people without typing experience seem to be able to approach the keyboard and peck out acceptable messages. But these few different kinds of skills exhaust the list.

## Our Communication Channels

Our experiments have tested four different channels of communication that mediate mechanically or electronically the four forms of natural human communication that I've just described. The four channels are video (the picture part of television without the voice), audio, handwriting, and typewriting. Three of the four basic channels have been tested singly, and all of them have been tested in various combinations. The individual channels or combinations of them are referred to collectively as modes. We have tested as many as 10 different modes in a single

experiment. As a standard of comparison, we typically rely on normal unrestricted face-to-face communication. In these control or face-to-face experiments, subjects are allowed to communicate in any way they like. They can talk, gesture, write notes to each other, or sometimes even typewrite to each other if they choose. Because the communication options are many, we usually refer to such face-to-face conditions as a communication-rich mode.

## The Communication Laboratories

The laboratory in which our early experiments were done consisted of two adjoining rooms connected by a sound-proofed double door (Figure 1).

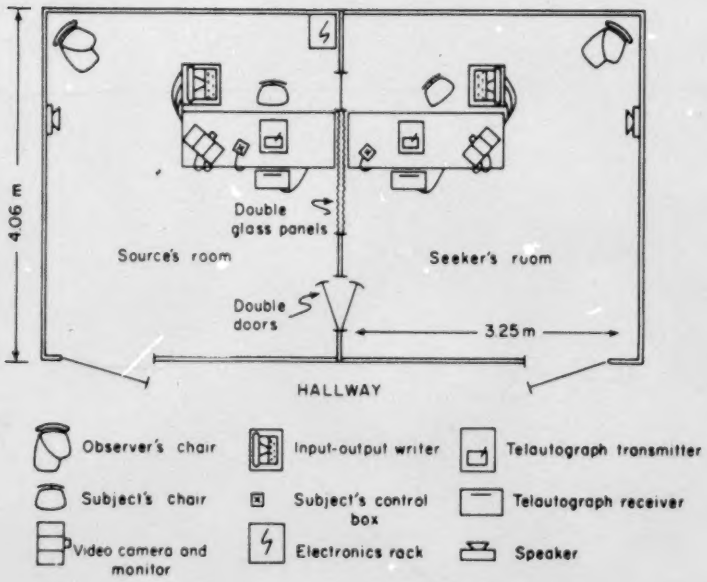


*Figure 1. The two experimental rooms and equipment used in our early work.*

The wall between the rooms also had in it a large double glass panel, which could be covered with an opaque screen so that the persons in each of the rooms could not see each other. When the panel was not covered, the participants could see each other and could converse freely through a microphone and loudspeaker even though they were separated physically. And, as I have said, in some of our experiments subjects have actually been face-to-face or side by side in the same room.

Figure 1 shows teletypewriting and telautograph machines. These machines are linked in such a way that anything typewritten or written in long hand on a machine in one room is simultaneously reproduced on the machine in the other room. Video cameras and monitors enable us to duplicate closed circuit television or to use either the video or audio channels separately. You can also see in a corner of each room a place for an observer. In some experiments, this person made activity analysis recordings of what the subjects were doing as they solved their problems. I shall have occasion to refer to these activity measurements later in my talk.

Three years ago, we expanded and redesigned our laboratories as shown in Figure 2. These facilities permit us to test people in as many as four different rooms. Communication facilities among the rooms allow all persons to communicate with all others, or allow only certain communication links to be used. The four subject rooms are separated by an observation room with one-way vision mirrors so that observers can see into each of the subject rooms.

## Problems

For our research we have generated a large inventory of tasks or problems. The problems vary in a number of dimensions. Perhaps the only feature they have in common is that they are all of recognizable practical importance. They are, in short, real-world, everyday problems about which you might want to have a conference, or problems that you might solve by communicating interactively with a highly sophisticated computer. Some problems are entirely clerical paper and pencil tasks, some involve mechanical manipulation, and others require careful attention to detail. Some have recognizable solutions, others have no definite solution. Some can be used only with two persons, others can be used with many persons. Some are factual and allow little room for argumentation, others are matters of opinion about which you might expect to disagree.

To give you some flavor of the kind of problems we have, let me first describe a few of our two-person factual problems. They are formulated in such a way that their solutions require the efforts of two persons working together as a team. This is done by deliberately structuring the problem so that each member of the team receives complementary information folios. One member of the team, the person we call the

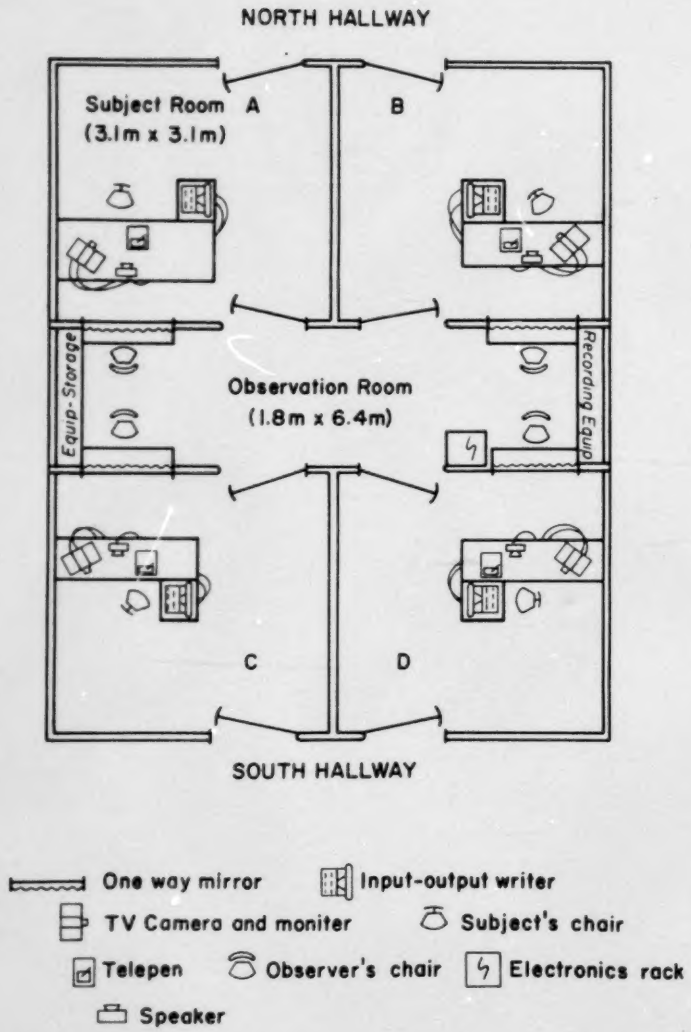


*Figure 2. The Communication Laboratories at The Johns Hopkins University.*

information seeker, is given a problem for which he has to find a solution. His information folio consists of certain parts of the problem. The other member of the team, the person we call the information source, has a folio with the remainder of the information needed to solve the problem. While neither person can solve the problem by himself, the two of them have all the information necessary to do so.

An illustration of such a problem is what we call our wiring task. The seeker is given a digital logic panel (Figure 3), and some wires with clip ends. When the panel is correctly wired as in Figure 4

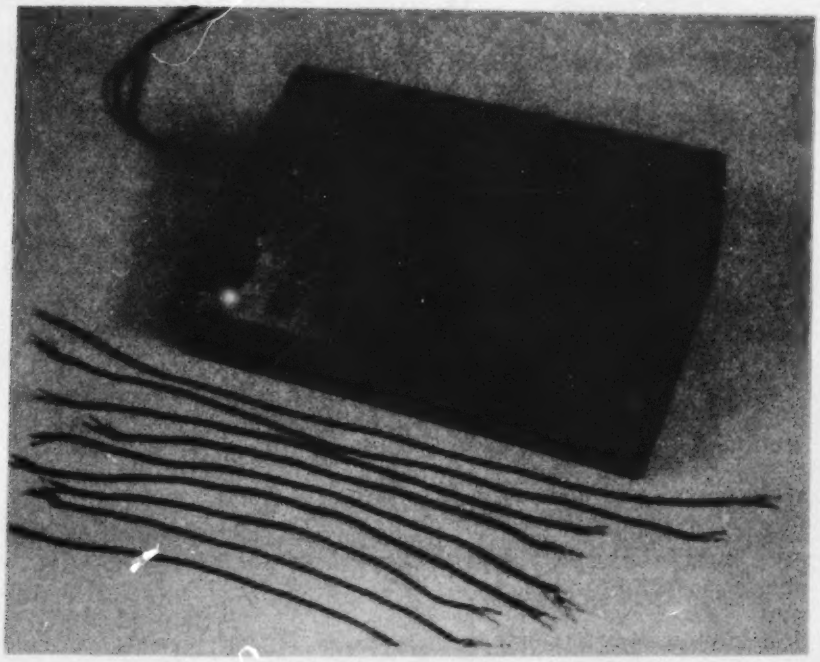

*Figure 3. A digital logic microlaboratory teaching device. This photograph does not show clearly the three different colors of connecting wires laid out below the circuit board.*

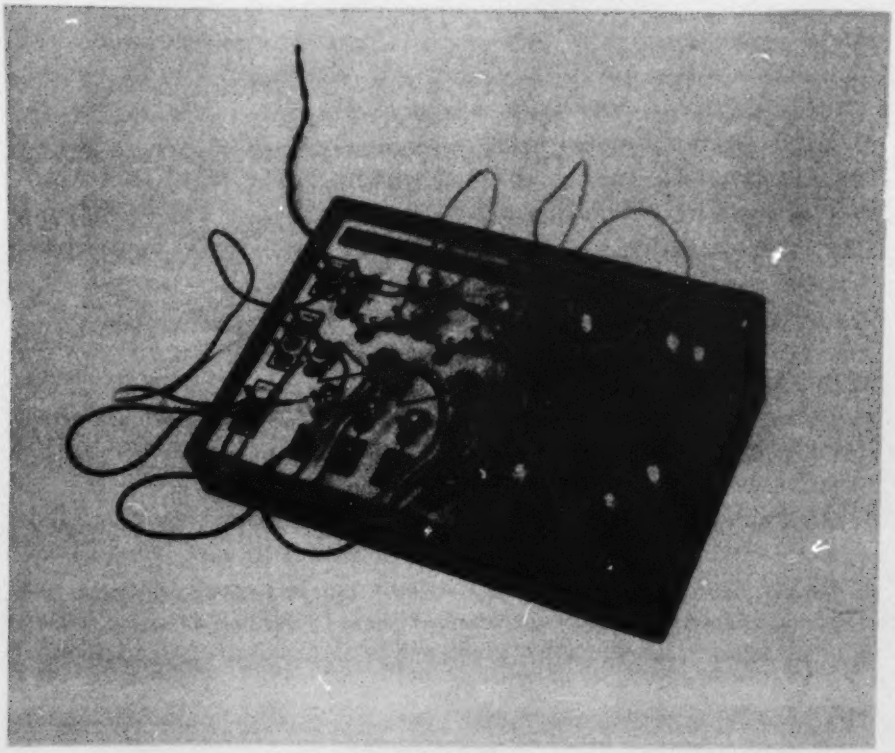

*Figure 4. When the device in Figure 3 is wired in this way, the circuit will count digits in the binary system.*

and the power is turned on, lights on the panel flash in sequence as the assembly counts digits in the binary system. Information about how to wire the panel is supplied by the source who has a complete and correctly wired panel at the start of the problem.

Another factual problem occurred to me from a personal experience. I had purchased an article from Sears Roebuck and the article came in a large box. When I opened the box I found that it consisted of a large number of disassembled parts, and some assembly instructions and diagrams. While my son sat on the ground and read the instructions to me, I tried to put the thing together. In Figure 5 you can see the partially

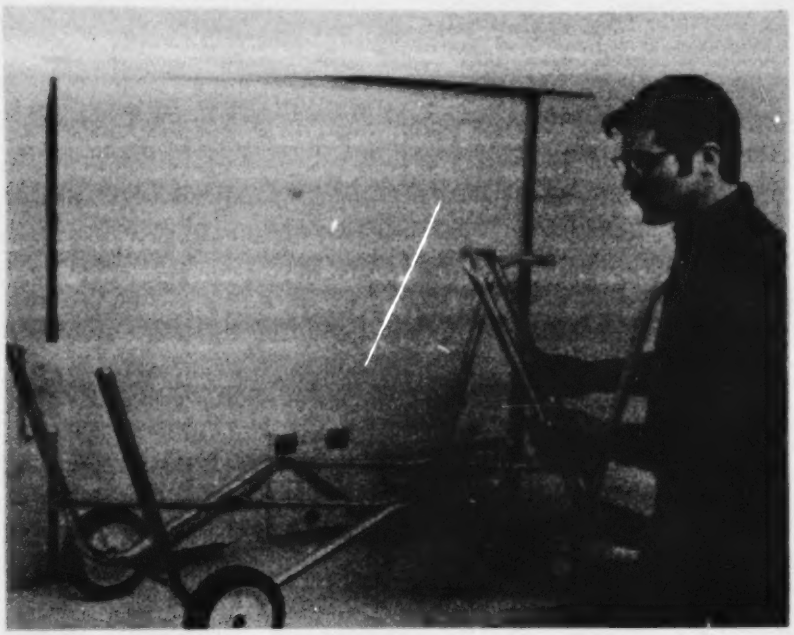

*Figure 5. A partially assembled device used in our equipment assembly problem.*

assembled device and in Figure 6 the fully assembled one. It's a trash toter designed for carrying trash containers from one's house to curb-side. We have used this problem many times with the seeker assuming my role and the source assuming my son's role. By the way, I did finally get my trash toter assembled.

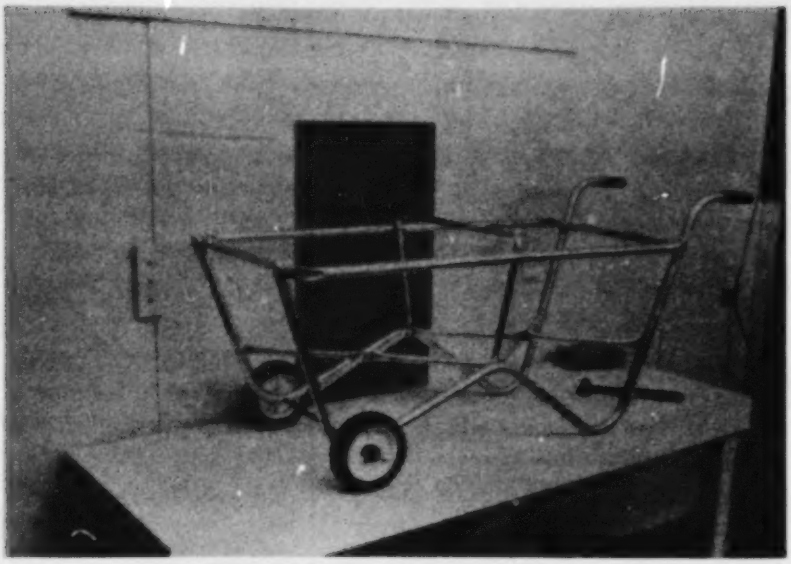

*Figure 6. When the device in Figure 5 is fully assembled it is a trash can toter.*

Our class scheduling problem is somewhat different. Here the seeker is given a list of four college courses that have to be arranged into a workable schedule within specified time constraints, such as commuting schedules. The source has a 97-page booklet listing the complete time schedule for courses at the University of Maryland. The courses and constraints are such that there is only one correct solution.

In our information retrieval problem, the seeker has to prepare a bibliography of newspaper articles on a specific topic. The citations have to be drawn from a huge reference volume in the source's possession. This volume lists by author, title and subject matter, all articles, editorials, and letters that appeared in The New York Times during one year.

Entirely different kinds of problems are those that provide a setting for argumentative discourse among communicators. The topical matter for discussion is picked to be relevant to the subject population, yet is sufficiently general in nature that none of the participants is likely to have an inherent advantage by virtue of specialized experience. The problems are also designed so that they can be used with 2, 3, or

4-person groups. Since there are no unique solutions to the problems, the subjects are left to debate the merits of alternative solutions until they arrive at a consensus or agreement.

One example of such a conflictive problem is what we call our national issues problem. The participants are asked to rank order the ten most important issues facing the United States today. An additional requirement is that the participants must rank order the issues not as they think about them privately but as they think the average undergraduate student had ranked them in a prior survey. The purposes of this latter requirement are to provide (a) an additional basis for argumentation, and (b) a basis for estimating the goodness of the solutions.

We have several variations of a budget negotiation problem. The following describes one that generates a considerable amount of interest among our undergraduate students. The students are told that the University's Director of Athletics must reduce expenses in a number of different areas of expenditure, for example, uniforms and equipment, athletic scholarships, and travel. The subjects are cast in the role of captains of various teams, for example, football and lacrosse, and they have to agree on the areas in which budget cuts will be made. The payoffs for the different subjects are different so that a cut in expenditure for transportation for the football team is not equivalent to that for the lacrosse team. Each subject knows his own payoff structure but not that of the other participants. Each subject's goal is to minimize the losses to his side, that is, to the team he is supposed to be captain of. Each subject's payment for participation in the experiment is reduced in proportion to the losses he sustains from the mutually agreed upon solution to the problem.

This description of some of our problems is perhaps sufficient to convey the flavor of the tasks that we provide for our subjects. Although I seem to have spent a fair amount of time talking about problems, I want to emphasize that our primary interest is not in problems, or in problem solving. Our problems merely serve as tasks, or vehicles for generating communication. Our aim in using a large variety of problems is to get greater generality for the variables we are primarily interested in. To anticipate one of our principal conclusions, we do find interactions between problems and some of our communication variables, but the interactions are rather few. For the most part, the communication effects that I shall talk about are extremely robust and hold for all the tasks and problems we have tested. That is a gratifying kind of generality to have.

## Other Experimental Conditions

Our experiments have been done on high school students from the Baltimore area and college students at Johns Hopkins. Students of both

sexes have been tested, and in some cases, subjects have been selected for particular intellectual abilities and skills.

Most of our experiments have been done with pairs of participants. Several, however, have been done with groups of as many as four subjects. Every experiment I shall talk about has been done with at least two different problems. In five experiments, subjects have been tested on as many as four consecutive days.

All our experiments are multivariate in design and the data have been analyzed by analysis of variance or multivariate analysis of variance techniques. Although I shall not dwell on statistical matters, unless I say otherwise, you may assume that all the effects I talk about are statistically significant. However, as you will see, most of our effects are not merely statistically significant, they are large and of practical significance as well.

## Communication in Diverse Modes

Figure 7 shows some findings from the first experiment we did in our program (Chapanis, Ochsman, Parrish & Weeks, 1972). Along the ordinate I have plotted mean time in minutes to solve problems. The data here are pooled for all teams that worked under each of the conditions and for the two different problems that were solved by the teams. From the labels on the abscissa, you can see that there were five groups of subjects. The left most bar is for subjects who worked in what we call our communication-rich mode. The second bar shows data for subjects who could communicate only by voice. These subjects could not see one another. The third bar is for subjects who communicated only by writing notes to one another, and the two bars on the right are for subjects who could communicate only by teletypewriter. You will notice that we tested two kinds of subjects in the teletypewriting mode: experienced typists and inexperienced ones. Our reason for doing that was that computer experts are often interested in the effects of typing skill on communication by teletypewriter.

One striking thing about the data in this illustration is that there are large differences among the various groups of subjects. Subjects who worked in the teletypewriting mode required, on the average, about two and one-half times as long to solve problems as did those who worked in the communication-rich mode.

One finding that at the time was a surprise to us was the very small difference between subjects who communicated in the communication-rich mode and those who communicated by voice only. We had been led to expect from the voluminous literature on this matter that non-verbal communication--gestures, movements of the body--would contribute greatly

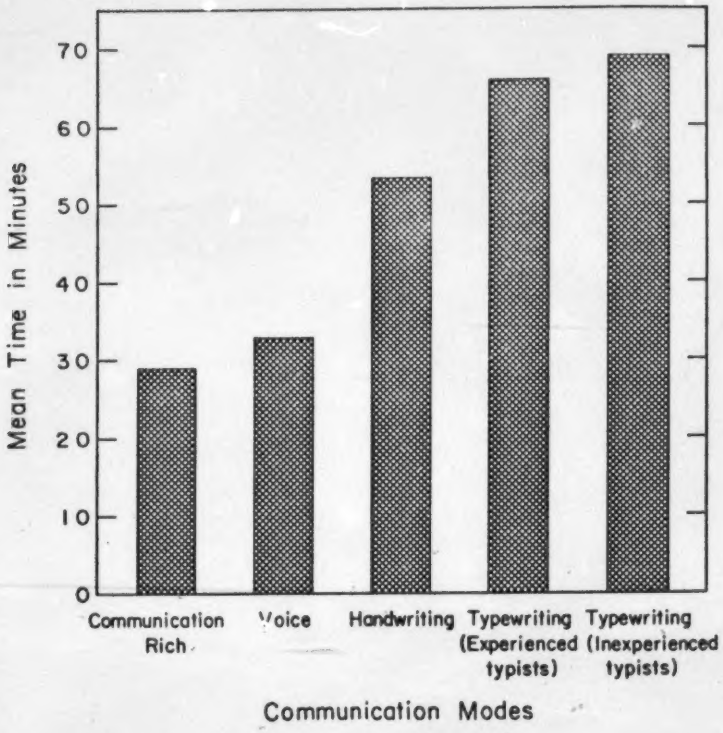


*Figure 7. Average times to solve problems in four different communication modes. Each bar is an average for four two-man groups and for two different problems. The teletypewriting mode was tested with subjects having different typing skills. (From Chapanis, Ochsman, Parrish, & Weeks, 1972)*

to the communication process. Our data here show that this is not so at least for our dependent measures. Subjects who communicated by voice only solved their problems almost as fast as those who communicated face-to-face.

At the time we were also surprised that the skilled typists did not do appreciably better than the unskilled typists in the teletypewriter mode. The difference you see here is neither statistically nor practically significant. That result so intrigued us that we did another experiment (Weeks, Kelly & Chapanis, 1974) to test it again. It's true. Typewriting skill is not very important for communication tasks such as these.

Finally, subjects who communicated in the two so-called "hard copy" modes, that is, handwriting and teletypewriting, took significantly longer than did those subjects who communicated in the two modes that had a voice channel. The finding that people can solve problems faster when they talk to each other than when they write or type to each other is not in itself particularly exciting or novel. However, that finding becomes much more interesting when it is considered in the light of other data that I shall talk about in a few minutes. So I would like you to keep this pattern of results in mind and to recall it in a little while.

My next figure (Figure 8) shows data from an experiment (Ochsman & Chapanis, 1974) in which we tested ten different modes of communication.

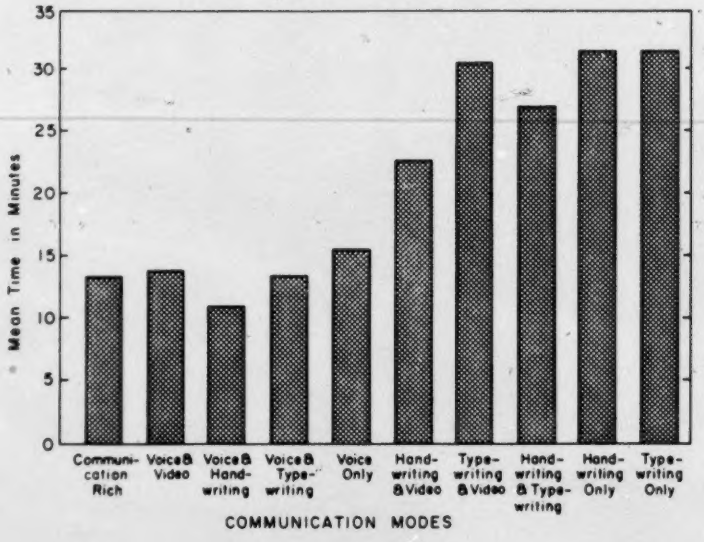


*Figure 8. Average times to solve problems in ten different communication modes. Each bar is an average for six two-man groups and for three different problems. (From Ochsman and Chapanis, 1974)*

The ordinate shows the mean time in minutes to solve problems by each of ten groups of subjects. As before, data are pooled for subjects and problems. In this case subjects solved three different problems. Along the abscissa, communication modes are arranged in a rough order of richness to impoverishment. On the far left are subjects who worked in a communication-rich mode, that is, they worked face-to-face and had available all the communication options that we provided in this experiment. The second bar is for subjects who communicated through a closed-circuit television system. They had both a voice channel and a video channel. The third bar shows data for subjects who had voice and handwriting channels, the fourth bar for subjects who had voice and typewriting channels, and the fifth bar for subjects who had only a voice channel. The next bar shows data for subjects who had available a video channel and an automatic handwriting system, that is, they could write to each other and could see each other as well. The next bar is for subjects who worked with teletypewriters but who also had a video channel, the next bar for subjects who could either use the teletypewriter or the automatic writing system, and the last two bars show data for subjects who had only the automatic writing system or the teletypewriting system.

There is only one statistically significant effect in this entire set of data. The times for the five conditions on the left are all significantly faster than for the five conditions on the right. What is common to the five conditions on the left? They all had a voice channel. What is common to the five conditions on the right? None of them had a voice channel. So once again, we see here dramatically the powerful influence of a voice channel on interactive communication.

Note incidentally the very small difference between the subjects who worked in the communication-rich mode and those who had only a voice channel. Subjects who had a voice channel did take a little longer than those who worked under communication-rich conditions but the difference is small and not statistically significant.

The next figure (Figure 9) shows data from still another experiment (Krueger & Chapanis, Note 1) in which three communication modes were tested, face-to-face, televoice, that is, a voice channel only, and teletypewriter. This experiment was done with conferences of two, three, and four persons and the data you see here are averaged for all these sizes of conference. My reason for showing this particular set of data is that here subjects who had only a voice channel actually solved their problems faster than did those who were face-to-face. The difference is not statistically significant, but it provides confirmation of the extremely small or non-existent difference that we consistently find between face-to-face and voice-only communication.

## Words, Words, Words

I asked you to remember a set of data showing mean times to solve problems in five communication conditions. Those data, you recall,

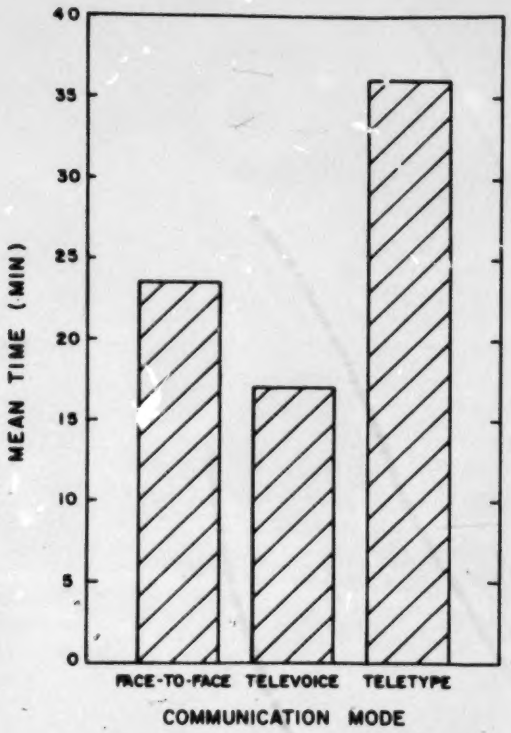


*Figure 9. Average times to arrive at consensus agreements in three communication modes. Each bar is an average for three groups, each of which worked at a different task on each of three successive days. Each set of three groups was made up of a 2-person, 3-person, and a 4-person group. (From Krueger and Chapanis, Note 1)*

showed that problems were solved fastest in the two communication modes that had a voice channel, and slowest in the hard-copy modes, that is, in the handwriting and teletypewriting modes. Now in this next figure (Figure 10) I show you another set of data from that same experiment (Chapanis, Parrish, Ochsman, & Weeks, 1977). These data are for the mean numbers of messages exchanged by the subjects in those conditions. By our definition, a message began when a person began to talk, write or type, and ended either when he had finished communicating or when he was interrupted. Here you see that the two communication modes that were fastest are characterized by the exchange of an enormous number of messages. By contrast, the communication modes that were slow had a relatively small number of messages exchanged.

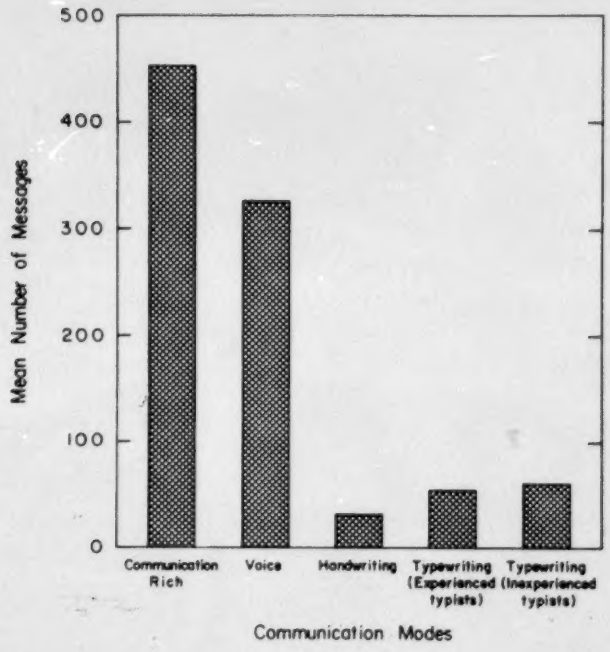


*Figure 10. Average numbers of messages exchanged in the solution of problems in four communication modes. These data and those in Figures 7, 11 and 12 are from the same experiment (From Chapanis, Parrish, Ochsman, & Weeks, 1977)*

This is a finding that has come up time and again in our experiments. Briefly, the finding is that those communication channels that are fast, that is, those communication modes that have a voice channel, are also characterized by their verbosity, no matter how verbosity is measured. The next figure (Figure 11) shows, for example, mean numbers of words, where you see a pattern similar to that for the mean numbers of messages. At this point, let me call to your attention one small feature of these data that will appear again. Notice that subjects who communicated in the voice-only mode actually used fewer words than subjects who were face-to-face. One might suppose that being face-to-face, and being able to use gestures and body language would reduce the number of words exchanged. That doesn't seem to be the case.

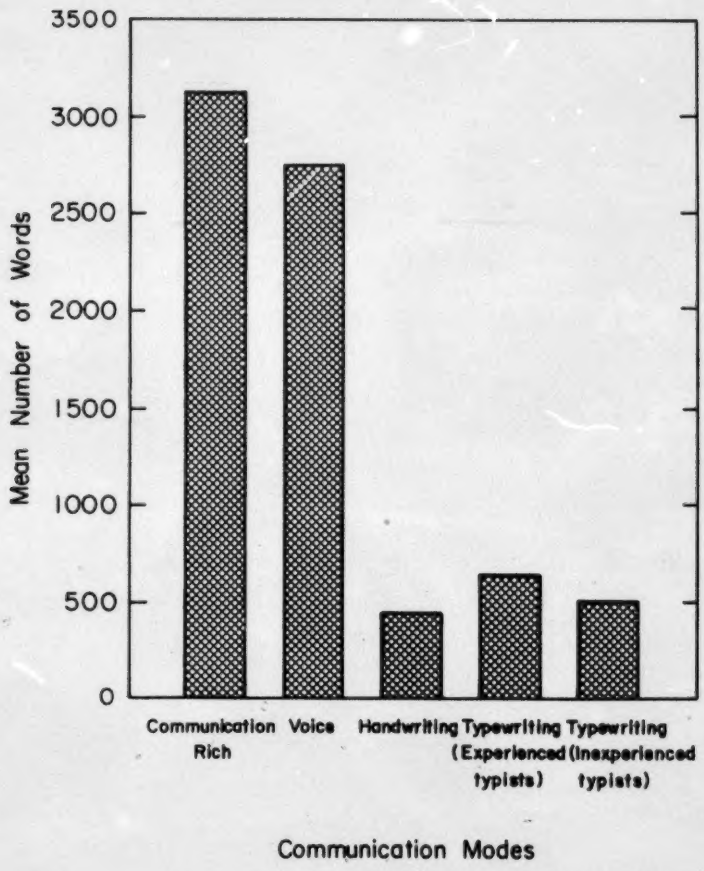


*Figure 11. Average numbers of words used in the solution of problems in four communication modes. These data and those in Figures 7, 10 and 12 are from the same experiment. (From Chapanis et al., 1977)*

Then from the same experiment, my next figure (Figure 12) shows communication rates in words per minute of actual communication time. Notice again the enormous difference between the two fast modes of communication, that is, those that have a voice channel, and the three slow or hard-copy modes of communication. The next figure (Figure 13) shows data from another experiment (Krueger & Chapanis, Note 1). Once again, you can see that the two communication modes that had a voice channel, that is, face-to-face, and voice-only, were characterized by a large number of

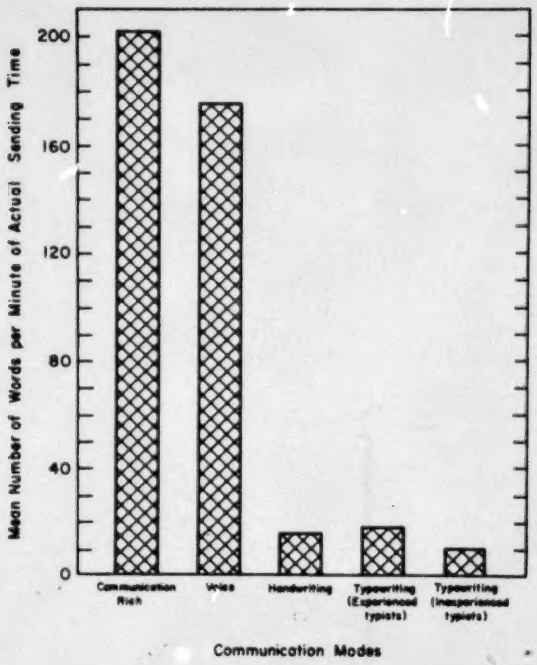


*Figure 12. Communication rates in the solution of problems in each of four communication modes. These data and those in Figures 7, 10 and 11 are from the same experiment. (From Chapanis et al., 1977)*

words, whereas subjects in the teletype mode of communication exchanged very few words on the average. Notice, too, that subjects who are face-to-face actually use more words than those who have only a voice channel and cannot see each other.

## The Medium or the Message?

An interesting point is that the number of words a person uses is determined by the kind of communication channel available to him and is apparently independent of the communication channel available to his partner or of the number of words received over that channel from his

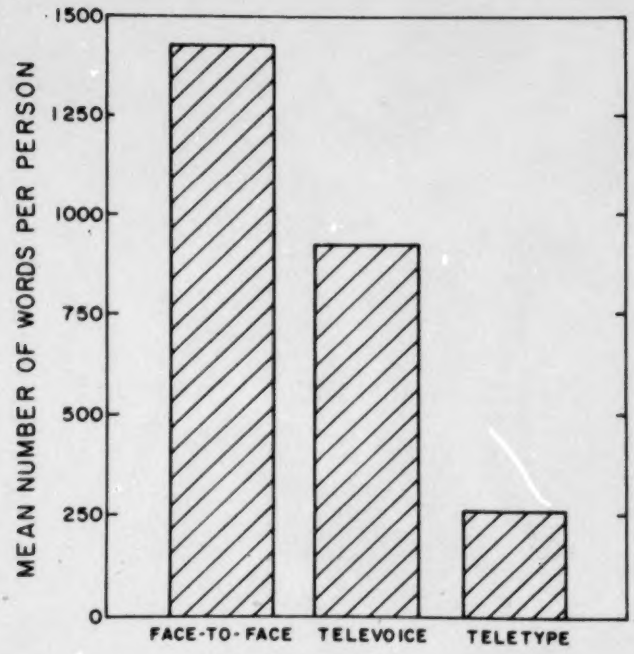


*Figure 13. Average numbers of words used in arriving at consensus agreements in three communication modes. These data and those in Figure 9 are from the same experiment. (From Krueger and Chapanis, Note 1)*

partner. For data on this point, I turn to still another experiment (Chapanis & Overbey, 1974). In this experiment, we had two-person teams communicate to solve one of four different kinds of problems. The information seeker in every case was the person with the problem to solve. The information source was the person who had the information necessary for the solution of the problem. In one condition (the left most pair of bars in Figure 14) both the seeker and source had voice channels. In another set of conditions (the pair of bars on the far right) they both had teletype channels. In the remaining half of the teams (the two pairs of bars in the middle), one of the communicators had a voice channel, the other a teletype channel. Now, in general, the sources used more words than did the seekers under identical conditions, but that is not the comparison in which I am interested. Look at the number of words used by

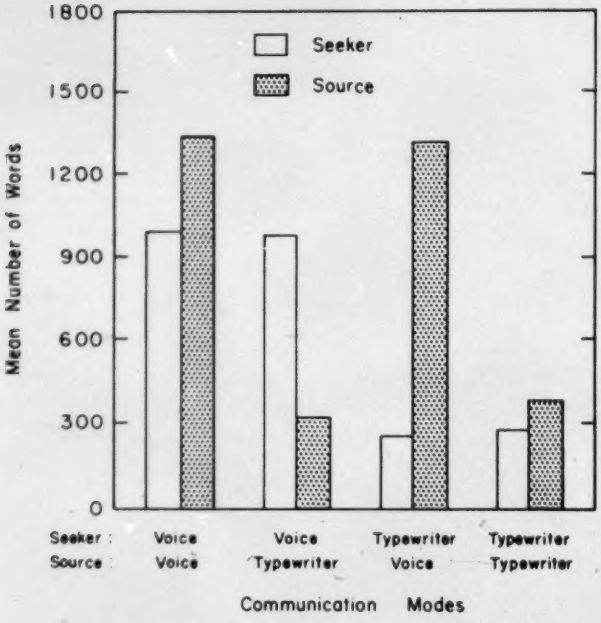


*Figure 14. Average numbers of words used by seekers and sources when two different channels of communication were tested in all combinations. Each bar is the average for eight subjects, two each of whom solved one of four different problems on one of four different days. (From Chapanis and Overbey, 1974)*

one communicator when his partner had either a voice channel or a teletype channel. Such a comparison can be made between the two open bars in the two left-most pairs of the figure. Notice that the numbers of words used by the seekers in both instances are almost identical although in one case the source had a teletype channel and in the other case a voice channel. Consider another pair of bars, the filled bars for the sources in the first and third pairs of data. Once again we see that the sources in these two sets of conditions used almost identically the same average number of words, although once again, the other member of the team had in one case a voice channel and in the other case a teletype channel.

Similar comparisons hold for the two open bars in the two right-most pairs of bars and the filled bars in the second and fourth pairs of bars. In every single instance the number of words used by a person is determined exclusively by the communication channel he had available and not by the communication channel available to his partner or by the number of words used by his partner.

## Why Do People Talk so Much and Write so Little?

I've shown you that one of the strong findings of the several experiments I have reviewed is that people who have a voice channel use far more words to solve a problem than do persons who have a teletype channel. Why is this? There are at least two plausible hypotheses. One hypothesis is that when we speak, the words disappear. They are evanescent. We cannot recapture them except in memory. When we communicate by teletypewriter, on the other hand, we make a hard-copy to which we can refer. So, one hypothesis is that we use far more words when we have a voice channel because of the limitations of memory. When we talk we have to repeat things and take many more words to get the same information across. Another hypothesis is that people who have a voice channel use far more words simply because it is so easy to talk. They use far fewer words when they type because of the effort required in the typing task itself. Which of these two hypotheses is more likely correct?

To test these hypotheses, we did an experiment (Ford, Chapanis & Weeks, in press) in which half the subjects solved problems as we had had them do in the past, either by voice or by teletype. These were our control subjects. The other half of the subjects in this experiment operated under quite a different set of rules. They were also required to solve the same problems but they started with a cash allowance at the beginning of the experiment and were told that for every word they used in the solution of the problem, we would deduct one penny from their initial cash allowance. At the same time, we also told the subjects that we would give them a bonus if they solved the problem correctly. So to maximize their pay, this group of subjects had to solve the problem correctly but had to do so with the fewest words possible. We provided them no instructions on how they were to limit their communications but simply let them decide that for themselves.

What were the results of this experiment? Some of the findings are shown in Figure 15. In the left-most pair of bars, you see the performance of the control subjects. As we have so often found in the past, subjects who communicated by voice used many more words than did those who communicated by teletypewriter. But now look at the pair of bars for the self-limited subjects, those who operated under the brevity incentives. Both groups of subjects, those who communicated by voice and those who communicated by teletypewriter, used far fewer words than did the subjects who communicated by teletypewriter under the control conditions. In fact,

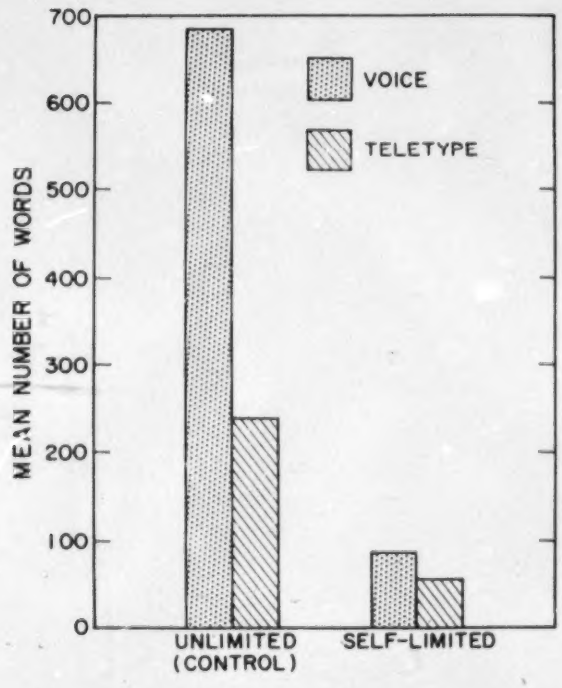


*Figure 15. Average numbers of words used by subjects who communicated either by voice or by teletype. The pair of bars on the left is for subjects who communicated without any restrictions; the pair of bars on the right for subjects who were penalized for every word they used. Each bar is an average for 16 subjects, males and females, and for two different problems. (From Ford, Chapanis, and Weeks, in press)*

the self-limited subjects who communicated by voice used only slightly more words than did those who communicated by teletypewriter. Incidentally, both the control and the self-limited subjects solved about the same number of problems correctly.

Another incidental finding of interest was that both the control, and the self-limited subjects took about the same average length of time to solve their problems. However, there were some interesting differences between the performance of the two kinds of subjects in the way

they allocated their time. The control subjects spent about 80% of their time communicating; the remaining 20% of their time was spent in pauses, that is, it consisted of time when nothing was being communicated. In the case of the self-limited subjects only about 20% of the total time was spent in communication. About 80% of the total time was silent time, that is, time when nothing was being communicated.

To sum up the results of this experiment then, it appears that the reason people use so many words when they communicate by voice as compared with when they communicate by hard-copy modes, is not so much because of the limitations of memory, but rather because it is so easy to talk. And, as we all know, given the freedom to talk, people will talk.

## Interruptions

Let me turn now to another variable: interruptions. In normal interactive communication, people tend to interrupt each other so often that we regard it as a rather normal part of the interaction process. Annoying perhaps, but normal. How important is it to have the freedom to interrupt? And, What happens to interactive communication when people do not have the freedom to interrupt? We have tested this question in two different experiments in somewhat different ways. In one experiment (Chapanis & Overbey, 1974), subjects communicated with each other either by voice or by teletypewriter. Half the subjects were free to interrupt at any time. So, for example, when subjects were communicating by voice, if A wanted to interrupt B, he merely pushed a button on his desk that cut off B's voice and allowed A to talk. B, in turn, if he wanted, could push a button on his desk to cut off A and restore the channel to him. In the teletypewriter mode similar interrupt capabilities were provided. If A was typing to B, and B wanted to interrupt, B pushed a button on his teletypewriter. This immediately locked A's keyboard and gave the channel to B. A, of course, could do likewise. If A wanted to interrupt B's communication, he merely pushed a button on his teletypewriter which locked B's keyboard and returned the channel to him.

The other half of the subjects in this experiment worked under what we call restricted interchange conditions. These subjects did not have the freedom to interrupt. If A was talking, or typewriting to B, B had to wait until A was through with his communication. When A was through, he pushed a button which released the channel to B. Similarly, if B was communicating to A, A had to wait until B was completely through with his communication, at which time B would push a button and release the channel to A.

The interesting and completely unexpected finding was that the subjects under the two conditions solved their problems in about the same time. Another surprise to us was that subjects in the two conditions used about equal numbers of words to solve their problems. However, there were some differences between the two conditions, and one important

difference was in the way words were packaged. Data in Figure 16 show the mean numbers of messages exchanged by the subjects under the free and restricted conditions. Here you can see that the subjects who were free to interrupt at any time used a lot more messages than did subjects who could not interrupt freely. Now keep in mind how this figure looks

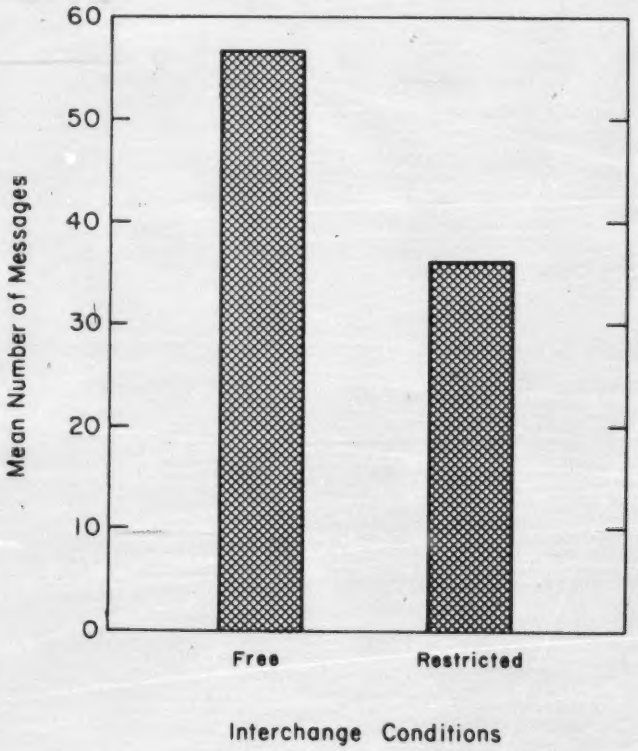


*Figure 16. Average numbers of messages exchanged under conditions of free and restricted interchange. Each bar is an average of 64 observations. Eight two-person teams each solved four different problems on four different days using each of the channel combinations illustrated in Figure 14. (From Chapanis and Overbey, 1974)*

when you compare it with the next one (Figure 17) in which I have plotted the average number of words per message. Here you see a reversal. When subjects are free to interrupt at any time, messages are much shorter than when they are not free to interrupt. If we take these two sets of

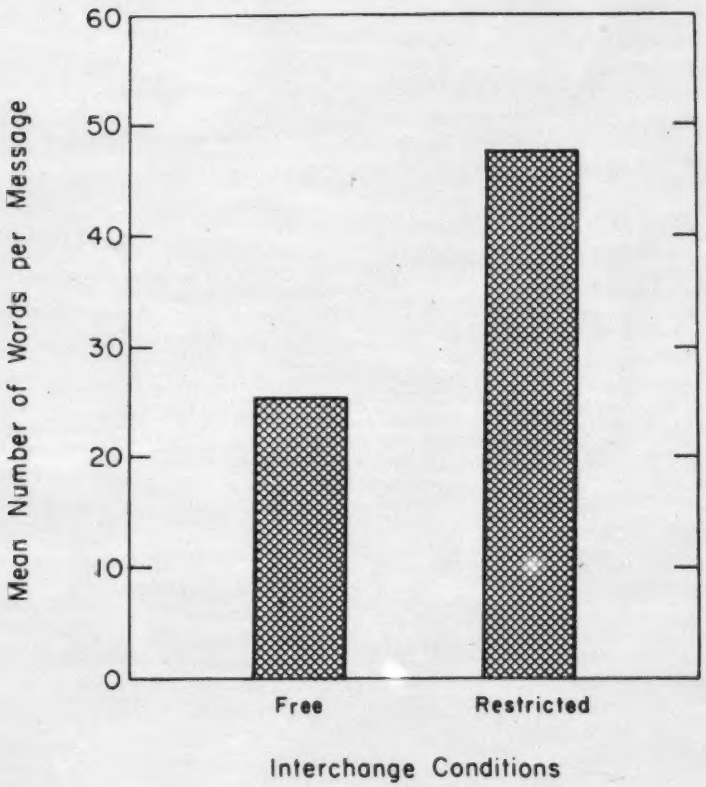


*Figure 17. Average message lengths for the same data as are shown in Figure 16. (From Chapanis and Overbey, 1974)*

data together, it turns out that when subjects were free to interrupt, they used far more messages and messages were shorter. When subjects were not free to interrupt, they had far fewer messages and messages were longer.

A different point about interruptions is nicely illustrated in the experiment in which we had tested 10 different modes of communication (Ochsman & Chapanis, 1974). In that experiment, we provided the subjects with two buttons. One button allowed a subject to give control of the channel to his partner; the other button allowed a subject to take control from his partner. Figure 18 shows data on the average number of button pushes of each kind in the 10 different communication modes.

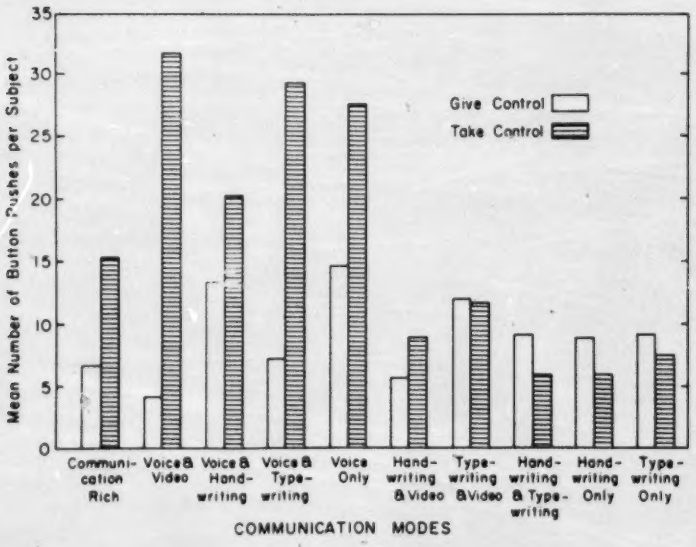


*Figure 18. Average numbers of times subjects either gave or took control of communication channels. These data and those in Figure 8 are from the same experiment. (From Ochsman and Chapanis, 1974)*

This is a rather complicated figure at first glance, but the point I want to make about it is fairly simple. Look at the five pairs of bars on the left. Notice that in each pair the open bar is much smaller than the filled bar. The open bars represent those instances in which subjects gave control of the channel to their partners, the filled bars are those instances in which subjects took control of the communication channel from their partners. Now look at the five pairs of bars on the right. What you see here is that the open and filled bars are about the same height. To be sure, there are some small differences between the pairs of bars, but the most striking characteristic is that the bars are more nearly of the same heights. Once again, what is it that the five communication modes on the left had in common? They all had a voice channel. What is it that the five communication modes on the right had in common? None of them had a voice channel. So what this set of data tells us is that when a communication mode has a voice channel, people take control of a channel much more commonly than they give control. When the communication mode does not have a voice channel, however, people are inclined to give or to take control about equally often.

## On Levels of Sophistication

In a number of our experiments, we have used activity sampling techniques to study what the subjects were actually doing during their problem solving tasks. This procedure is borrowed from those commonly used in human factors engineering, or industrial engineering. An observer sitting in the room with the subject has an earphone into which is fed a tonal signal every five seconds. When the signal comes on, the observer records in coded form precisely what the subject is doing at that time. In Table 1 you see some of the kinds of behavior categories we have recorded in our experiments. These, of course, are only capsule titles. Each kind of behavior is thoroughly described in about a paragraph so that the observer knows precisely what it is that he is supposed to be recording. I don't really want to dwell on these behavior categories. You can read about them elsewhere if you're really interested. What I want to do is to tell you about an interesting set of findings that we have observed with that technique.

The experiment I want to talk about was designed to find out whether the level of sophistication of communicators affects communication and problem solving in our kind of situation (Parrish, 1974). The pairs of subjects in this experiment were made up of various combinations of high school and college students who served as seekers and as sources. In Figure 19, you can see that teams made up of college students arrived at solutions fastest. High school teams were slowest. When teams were mixed, that is when the teams consisted of one high school and one college student, solutions were faster when the college student served as the source. Other data lead us to conclude that these findings can be explained by the greater facility college students have in using language. In these problems, the source was given the bulk of the library-like or stored information. It was he who gave directions or instructions to the

Table 1

Examples of Behaviors Recorded With Our Activity Sampling Methods

| |
|---|
| Sending |
| only |
| and searching, e.g., talking and looking through an information folio |
| and handling parts |
| and making notes, e.g., talking and making notes |
| pause, i.e., a pause in a communication |
| Receiving |
| only |
| and searching, e.g., listening and looking through an information folio |
| and handling parts |
| and making notes |
| Searching |
| only |
| and making notes |
| Handling parts |
| Making notes |
| Waiting |
| Other activities |

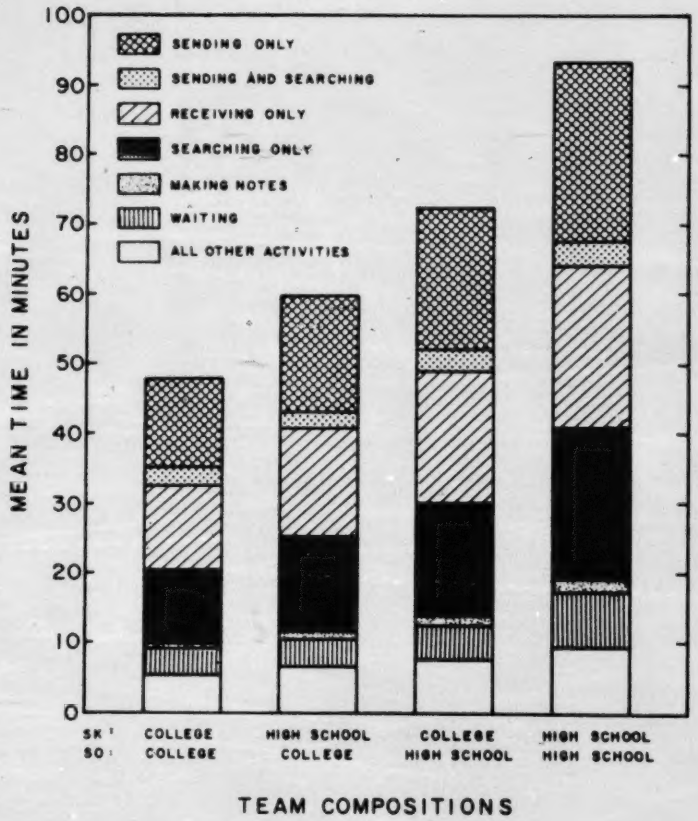


*Figure 19. Times to solve problems by combinations of high school and college students. The different segments of the bars show the amounts of time spent in each of seven different activities. (From Parrish, 1974)*

seeker about how to complete the problem at hand. The college students were better than the high school students at doing that.

The bars in each case have been segmented to show the various amounts of time spent in each of seven different activities by the teams

that solved these problems. If we now convert these bars to percentages, we get the results shown in Figure 20. The four bars here are so nearly alike that they seem to be traced from the same pattern. What do these

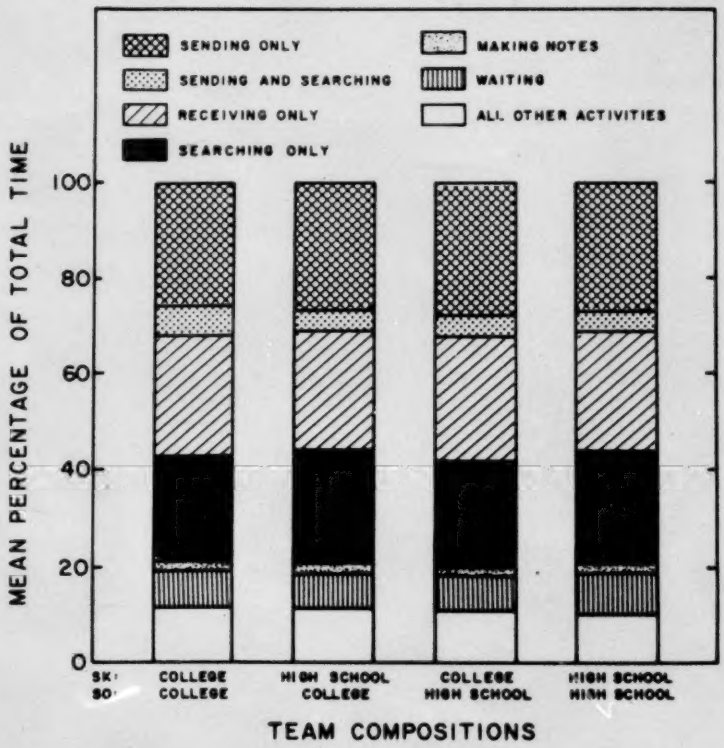


*Figure 20. The data of Figure 19 are here shown as percentages. (From Parrish, 1974)*

two sets of data together tell us? They tell us that in these communication tasks college students and high school students do about the same kinds of things and in about the same proportions. However, college students do everything faster.

## Are Some Communication Modes More Impersonal than Others?

It has been claimed that teletype or computer conferencing is more egalitarian and democratic than face-to-face communication. We have some support for that claim from one of our experiments (Krueger & Chapanis, Note 1). This experiment involved conferences among two, three, and four persons. For this experiment, we computed a coefficient of variation, that is, the amount of variability (measured by the standard deviation) in the numbers of messages produced by the various communicators when that variability has been compensated for the average number of messages (the mean). Larger values of this coefficient indicate greater disparity in the numbers of messages produced by the several communicators. Smaller numbers mean that the several communicators shared more equally in the production of messages.

The data from this experiment are shown in Figure 21 for three communication modes, face-to-face, televoice and teletype. Since there were no significant interactions involving the size of groups, the data here are averages for all three sizes of group. As you can see, the average coefficient of variability is highest for subjects in the face-to-face mode, intermediate for those in the televoice mode, and smallest for subjects in the teletype mode. Subjects in the teletype mode were much more likely to generate about equal numbers of messages than were those in either of the two voice modes.

## Bigger Conferences are Wordier

What happens when you increase the number of conferees in a teleconference? We've done one experiment (Krueger & Chapanis, Note 1) that systematically compared the performance of two, three, and four person groups meeting face-to-face, by televoice, or by teletype. In Figure 22, you see data on the mean numbers of messages for the two, three, and four person groups averaged over all communication modes. There is an almost linear increase in the number of messages exchanged as the size of the conference increases. The same is true for the number of words per group (Figure 23). If we now divide the average number of words per group by the number of people in the group, we get the data shown in Figure 24. These data say that on the average the number of words spoken per person is independent of the size of the group. It's as though, on the average, each person in a conference had a certain number of words to say. The reason larger conferences are wordier is simply that there are more people participating in the conference.

The interpretation that I have just given you does not literally mean that each person added to a conference group produces the same

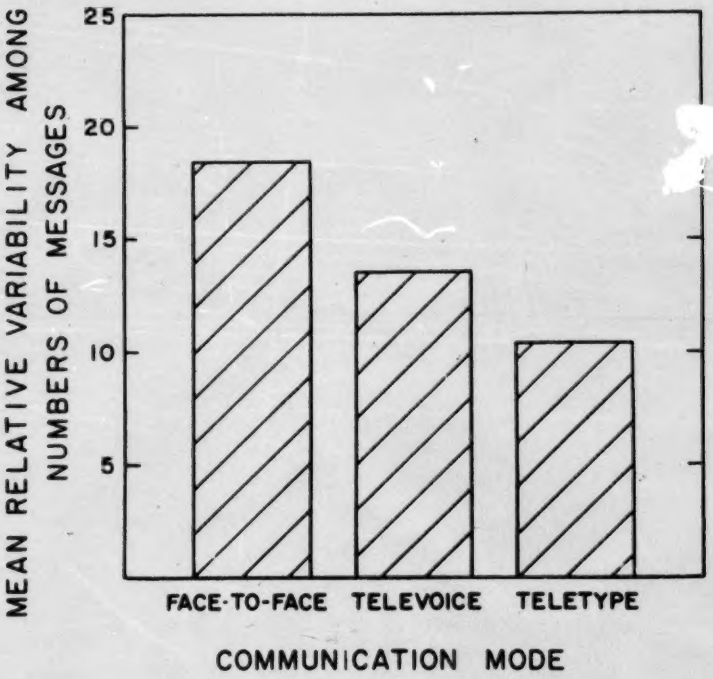


*Figure 21. Average relative variabilities among the numbers of messages produced in three modes of communication. Each bar is the average of 54 data points. Data are averaged for three sizes of conference group, each of which arrived at solutions to three different problems on each of three successive days. These data and those in Figures 9 and 13 are from the same experiment. (From Krueger and Chapanis, Note 1)*

average number of words or of messages. The increase in group verbal productivity as the size of the conference group increases may not be directly attributable to the addition of other speakers as to the addition of other listeners. The group verbal output is not shared equally by

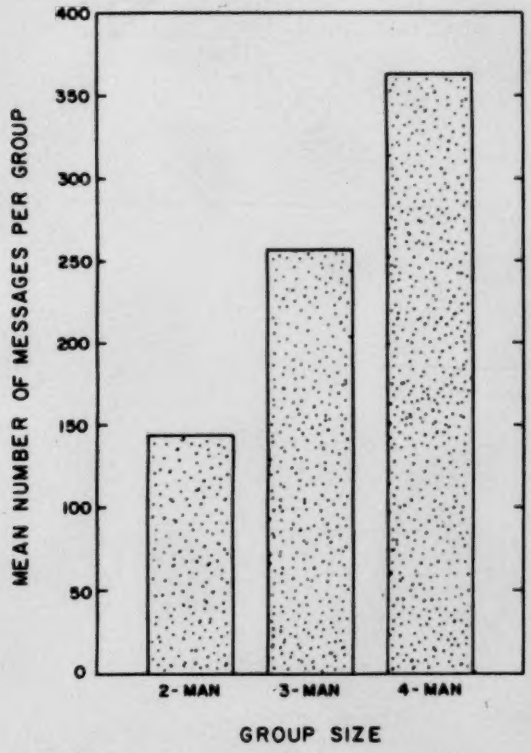


*Figure 22. Average numbers of messages exchanged by groups of two, three, and four persons. These are data averaged for conferences held in three communication modes: face-to-face, televoice, and teletype. These data and those in Figures 9, 13, and 21 are from the same experiment. (From Krueger and Chapanis, Note 1)*

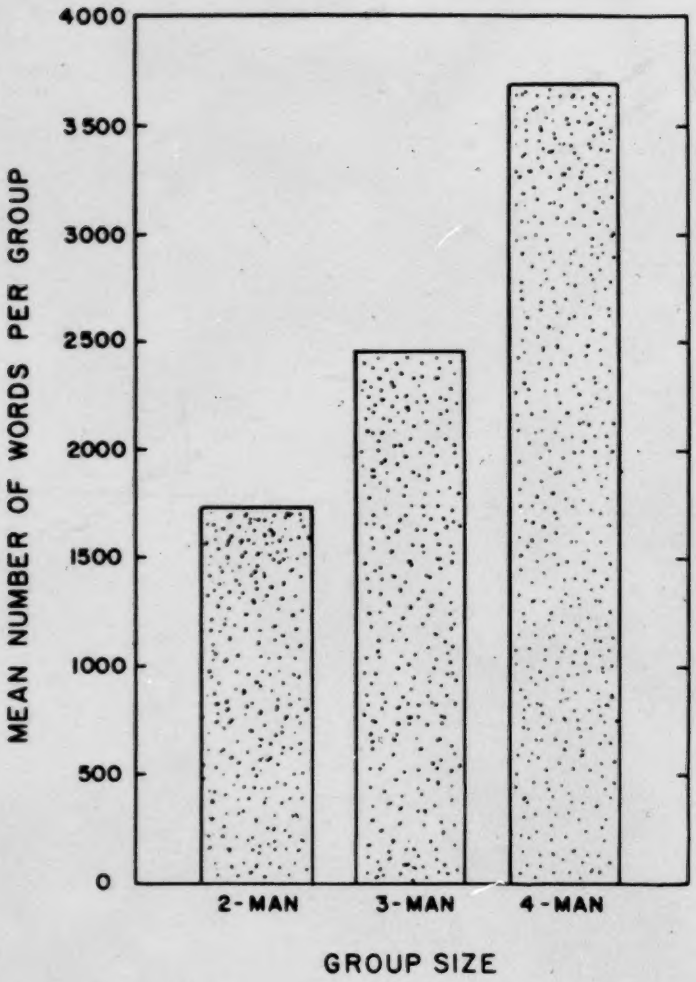


*Figure 23. Average numbers of words produced by the same subjects as those in Figure 22. (From Krueger and Chapanis, Note 1)*

all persons in the group. Figure 25 shows the relative disparity among conferees as the size of the conference group increases. Here you can see that the disparity increases systematically for the two, three, and four person groups. This means that as conference groups increase in size, some people become relatively more silent and others become relatively more verbal.

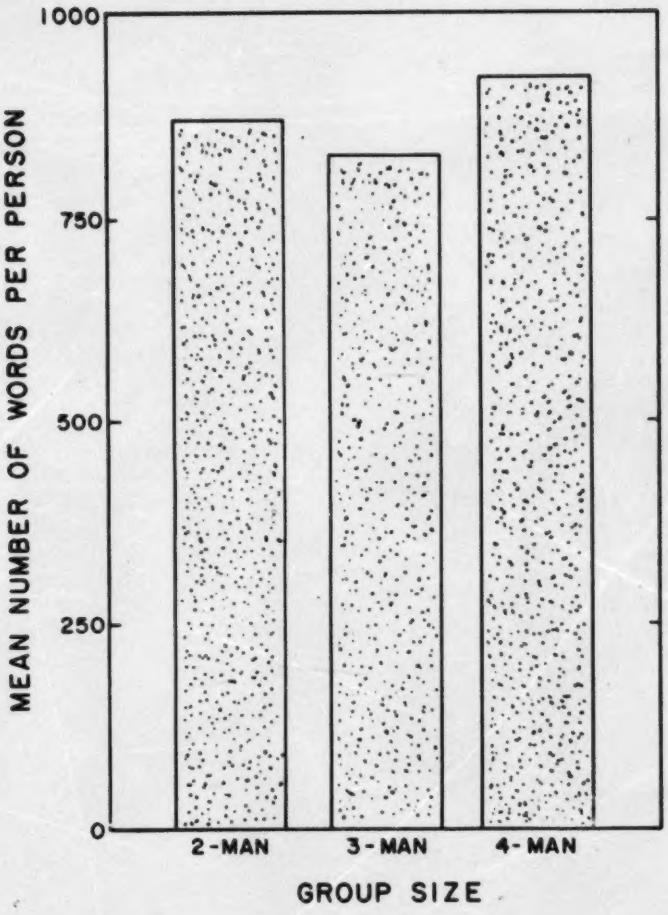


*Figure 24. The data in Figure 23 have been here expressed as the average numbers of words produced per person. (From Krueger and Chapanis, Note 1)*

## The Unruliness of Natural Communication

I have spoken rather glibly several times about numbers of words as though it were no trouble at all to count them. If you think that's so, it may be in part because most psycholinguistic studies are done with

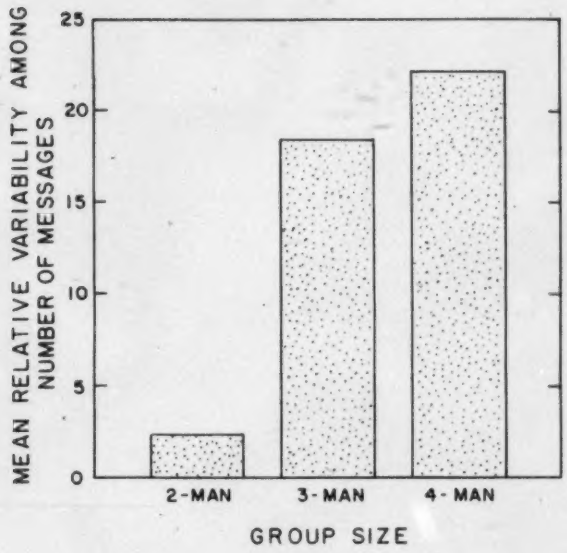


*Figure 25. Average relative disparities among the numbers of messages used by communicators in two, three, and four person conferences. These data and those in Figures 9, 13, 21, 22, 23 and 24 are from the same experiment. (From Krueger and Chapanis, Note 1)*

what I call "immaculate prose." Words are formed into perfect sentences, with subjects, verbs, and objects all in their proper places. Natural human communication is not like that at all. Most of us know that ordinary communication tends to be somewhat disorganized, but few of us really appreciate how disorganized it can be. Many of our protocols contain not a single grammatically correct sentence. Moreover, we find every role of spelling, abbreviation, punctuation, and format repeatedly violated.

Figure 26 shows the start of some interchanges between two persons who communicated via teletypewriter to solve a faculty selection problem. Figure 27 shows the start of interchanges between two persons who communicated by voice to solve an object identification problem. These are

SK: Need information . Use form of a list for clarity. Present info on all candidates in the area of research each has done..

end my typing go.

SO: A: The Eskimo as a Minority Worker in Alaska
Sikudaruty (Ignore) Solidarity Fornation Between Blue and White Collar Workers in Adverse

SK: wait////////////// ignore info about topics ... Can you give data of 1. quantity of research done as manifested in # of publications etc. If not, move on to (past experience in teaching) present in same fashion..... Please give SYNOPSIS of material for efficiency/////tttttt

SO: A: 3 publications
B:none
C: 3 pub.
D: 4 publ.
E: Dissertation research: The Existance of a Pecking Order in Penal Cloonies

SK: Information on AWARDS RECEIVED BY ANY OF CANDIDATES OR HINT OF QUALITY OF RESEARCH ? Then move on to teaching

SO: A: Best Paper, honor graduation, member of 2 Honor Societies
B:Phi Beta Kappa, most promissing grad, cited for contribution to science
C:Top 5%of class, Phi B K
D:

SK: from what institutions ? TYPE FASTER TURKEY go

SO: First change above ~~A~~ A, B, C to B, C, D Sorry

SK: ok go

SO: B: Grad from Duke Unev.
C: Harvard and Oxford
D:Univ. of Montana, Cornell
E:U. of Calif at Berkeley , UCla

*Figure 26. Start of the interchanges between two persons who communicated in the teletypewriter mode to solve a faculty selection problem. On the original protocol the seeker's messages (SK) were in black type, the source's (SO) in red. In this reproduction only the vertical spacing has been altered to make the typing somewhat more regular than it really was. (Unpublished data from Ford, Chapanis, & Weeks, in press)*

SO: Well, it's, it's a clip now, right?

SK: Yeah, it's a clip.

SO: How how wide is the clip?

SK: It's ah, a little bit wider than than the socket.

SO: How does it fit now, does it fit...Is it go on the bottom of it or it's it's definitely parallel to it?

SK: Right.

SO: It's definitely parallel

SO; to it?

SK: It's

SK; parallel so that when you clip it...

SO: Okay I got you, but it's wider than it right?

SK: Yeah, a little bit wider.

SO: A little bit wider.....Okay wait a second. Uh how wide is the socket is it, you know the socket itself

SO; is it/

SK: Okay

SO; wide or thin cause I have uh two two just about like that, what you described.

SK: Okay now, uh there's a socket and then there's a clip...

SO: I have the clip on and everything I've got that.

SK: Right. Okay now perpendicular to the socket there are two flanges...

*Figure 27. Start of the interchanges between two persons who communicated by voice to solve an object identification problem. SO refers to the source; SK to the seeker. Braces on the left identify instances in which both the source and seeker were talking at the same time. A semicolon indicates a message that continues without interruption the text above it. A solidus (/) indicates that a speaker was interrupted at that point. The numbers of dots are proportional to the lengths of pauses in the conversations. (Unpublished data from Ford, Chapanis, & Weeks, in press)*

typewritten protocols made from tape recordings and the punctuation has been added by the experimenters on the basis of their best judgment of what was intended. Figures 28 and 29 are segments of two protocols from persons who communicated by telepen to solve the wiring problem illustrated in Figures 3 and 4. The protocols in Figures 26, 27 and 28 are typical of what you get in these various kinds of studies. Figure 29 is an example of how bad protocols can get.

Two things impress us about natural communication. First, of course, is its unruliness. It is often difficult to know what to count as a word, sentence, or message. I think we've made a good start on that problem by formulating a series of rules that we use in our work. In any event, the natural unruliness of normal human communication has some important implications for the design of so-called natural language computers. If such computers are really going to interact with people in human-like terms, they are going to have to be much more forgiving and tolerant of human errors.

The second thing we find impressive about natural human communication is how easily, and how readily, people ignore or read through mistakes. Despite the apparent unruliness of normal human communication, there are obviously rules, because problems get solved, and get solved with surprising ease. Finding and describing the rules of normal human communication still remains an interesting challenge.

## The Essence of Brevity

Most recently, we have been doing some experiments that bear on languages for interactive computer dialogues. In somewhat oversimplified terms, the problem is this: Since no computer can yet handle all the words in the English language in all their possible connotations, any program for natural-language interactions must of necessity have a restricted vocabulary. How much can you restrict vocabularies without impairing the effectiveness of human communication? And, If you use restricted vocabularies, what words should be contained in those vocabularies?

We've done two different experiments on these problems. In one (Kelly & Chapanis, 1977), we allowed one third of the subjects to communicate with no vocabulary restrictions. One third of the subjects were allowed to use only words from a 500-word vocabulary and one third were allowed to use only words from a 300-word vocabulary. The vocabularies, I might add, were vocabularies that we made up empirically from the vocabularies actually used in our own experiments. The vocabularies did not come from established word lists, such as the Davis Howes or Kucera-Francis word lists. In fact, the words we allowed our subjects to use do not agree closely with the most common words in those two well-known word lists. By way of a brief procedural note, messages from each subject

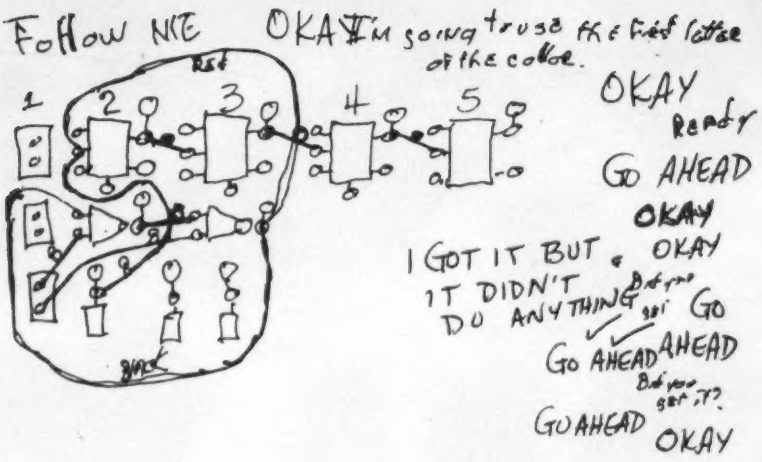


*Figure 28. One segment of a telepen protocol made by two persons who solved the wiring task illustrated in Figures 3 and 4. This black-and-white illustration does not show that messages from one person were in blue ink, by the other in red ink. There are 14 separate consecutive messages here with each communicator in turn adding to previous messages. (From Hoecker, unpublished data)*

went through a computer which scanned the message for illegal words, i.e., words not on the assigned vocabulary list, or words that were mispelled. If there were no illegal words, the messages were transmitted instantaneously. If any message contained one or more illegal words, the message was returned to the sender with a listing of the illegal word or words. And one final procedural note: Before the experiment began, subjects were trained in the words they were allowed to use.

One of the surprises to us was that subjects solved problems equally fast under all three conditions of vocabulary restriction. Much more impressive, however, was the evidence this study provided for the great flexibility and individuality people show in their choice and use of words even when they work at the same tasks and are greatly restricted in the words they can use (Michaelis, Chapanis, Weeks & Kelly, 1977). For example, what would you suppose is the size of the common vocabulary,

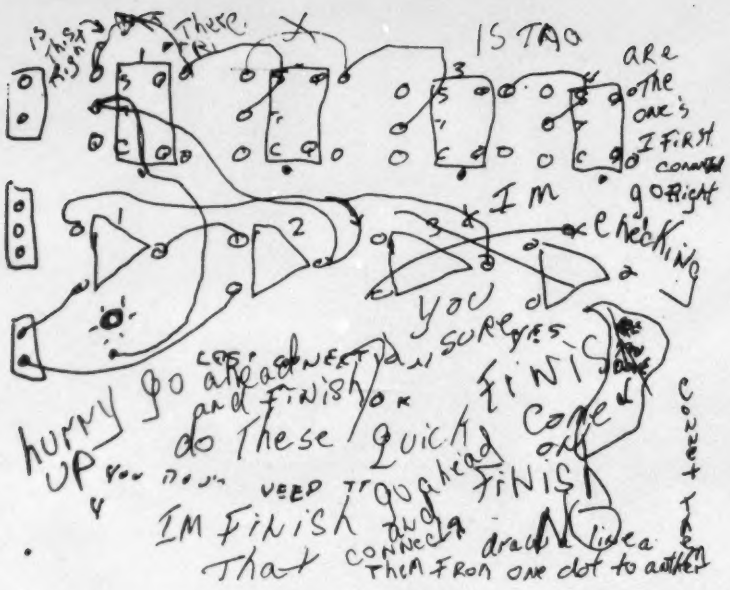


*Figure 29. A segment of an extremely disorganized protocol from the same experiment that produced the protocol in Figure 28. (From Hoecker, unpublished data)*

that is, the number of words used by every one of the subjects in this study? Remember that one-third of the subjects were limited to no more than 300 words. I'll pause for a moment while you think about the number of words that must have been used by every one of the subjects. Do you have a figure in mind? Did you think of the number four? That's all there were: And, I, is and to.

In the experiment I've just described, we, the experimenters, gave the subjects a restricted vocabulary. There is another way of looking at the same problem, and that is to allow subjects themselves to pick the words they will use if they deliberately restrict themselves. I've already described one set of findings from the experiment in which we rewarded brevity (Figure 15). Let me tell you about what happens to the kinds of words and messages people use when they deliberately try to use as few words as possible.

First, we went through all our protocols from this experiment and classified every word into one of nine parts of speech. Figure 30 shows

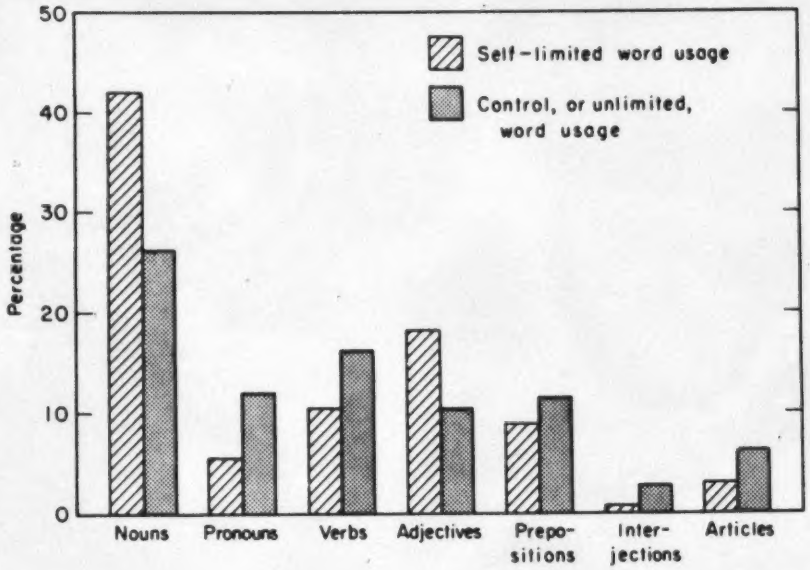


*Figure 30. Percentages of various parts of speech used by subjects who communicated with no vocabulary restrictions, and by those who limited themselves in the numbers of words they used. These data and those in Figure 15 are from the same experiment. (From Ford, Weeks, & Chapanis, in preparation)*

some of the statistically significant differences we found between the kinds of words used by subjects under the two conditions. Here you can see that when subjects limit their word usage, they use a much greater proportion of nouns and adjectives. At the same time they use significantly fewer pronouns, verbs, prepositions, interjections, and articles.

To get at the content of the messages that were exchanged, we devised a new way of classifying messages, sentences, or fragments of

sentences. We went through all the protocols again, this time classifying every unit of communication into one of these 11 classifications. Figure 31 shows the statistically significant effects that we found with

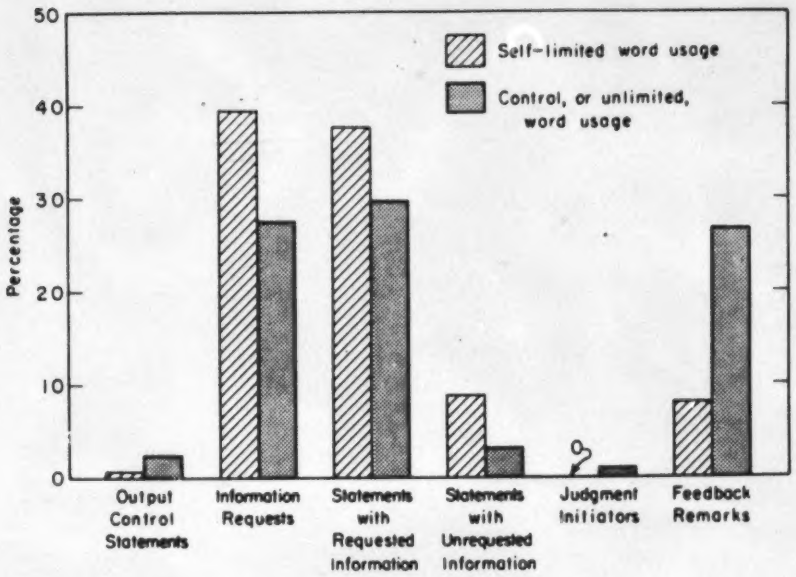


*Figure 31. Percentages of various kinds of statements by the same subjects as those who yielded the data in Figure 30. (From Ford, Weeks, & Chapanis, in preparation)*

this analysis. When subjects try to be brief, they use a much greater percentage of statements that are information requests, statements with requested information, or statements with unrequested information. On the other hand, when subjects are unrestricted in their use of words, significantly greater percentages of their messages consist of what we call output control statements ("go faster," "Slow down,") judgment initiators ("What do you think") and feedback remarks ("Right," "Ok").

Together, these two findings are, I think, beginning to give us some inkling of what constitutes the essence of brevity. I think we know better now how we should go about picking restricted vocabularies for human use.

## Conclusions

In this talk, I've only been able to touch on some highlights of our research and our findings. Let me conclude with a baker's dozen of what I think are significant findings. As is so often the case, some of my conclusions will seem like obvious ones, that is, they are obvious now that we have the data. However, they were not so obvious before we had collected the data. Anyway, here they are:

1. Problems are solved much faster in communication modes that have a voice channel than in those that do not.

2. Modes of communication that have a voice channel are much wordier than those that do not have a voice channel.

3. The wordiness of voice modes of communication appears to be due to the fact that it's so easy to talk. For none of the problems we have tested, do we find evidence that hard copy modes of communication are brief because they provide a hard copy to which you can refer later.

4. For none of the many problems we have tested can we find any significant advantage of face-to-face communication over communication by voice alone.

5. The number of words used by a communicator is a function of the communication channel available to him and is not influenced by the channel available to his partner, or by the number of words used by his partner.

6. Giving communicators the freedom to interrupt has no demonstrable effect on problem solution time or on the number of words used in the solution of problems. Words are, however, "packaged" differently. When communicators have the freedom to interrupt, they use more messages and messages are shorter. When communicators do not have the freedom to interrupt, they use fewer messages and messages are longer.

7. Communicators are much more likely to take control of a communication system, that is, to interrupt, if the system has a voice channel. Communicators relinquish control of a system about as often as they take control if the system has only hard-copy channels of communication.

8. In our communication tasks, college students and high school students do about the same kinds of things, and in the same proportions. College students, however, do everything faster.

9. Communicators in teletype modes of communication are much more likely to share equally in the exchange of information than are communicators in face-to-face or voice only modes of communication.

10. Natural human communication is extremely unruly and repeatedly violates conventional grammatical, syntactic and semantic rules.

11. People can communicate and solve problems effectively with far fewer words than they normally use.

12. Even when people are restricted in their use of vocabulary, they show flexibility and individuality in their choice and use of words.

13. The essence of brevity seems to consist of using more nouns and adjectives at the expense of other parts of speech, and in using more statements concerned with the exchange of information at the expense of control statements, judgment initiators, and feedback remarks.

## Epilogue

As is so often the case with basic research, the questions that have occurred to us are far more numerous than the answers we have found. I'm sure that many such questions have occurred to you as I have been talking. Let me close with just two that particularly intrigue me:

1. What are the rules of normal unrestricted human discourse? How do we read through errors, and wherein lies the information of ordinary unrestricted human communication?

2. So far as I know, research such as I have described has been done only for English-speaking persons. What would we find if we were to repeat these experiments in French, German, Arabic, Hebrew, or, for that matter, Black English and Chicano? No one knows.

If we knew the answers to these and still other questions, we would be much better able to speak to other people, people would be better able to speak with and through machines, governments would be better able to communicate with people, and governments would be better able to communicate with other governments. And that, I think, is what a lot of psychology is all about.

## Reference Note

1. Krueger, G. P., & Chapanis, A. Conferencing and teleconferencing in three communication modes as a function of the number of conferees. Manuscript submitted for publication, 1978.

## References

Chapanis, A. Prelude to 2001: Explorations in human communication. American Psychologist, 1971, 26, 949-961.

Chapanis, A. The communication of factual information through various channels. Information Storage and Retrieval, 1973, 9, 215-231.

Chapanis, A. Interactive human communication. Scientific American, 1975, 232(3), 36-42.

Chapanis, A. Interactive communication: Some findings from laboratory experiments. Conference Record of the 1976 National Telecommunications Conference, 1976, 2, 17.1-1 - 17.1-9.

Chapanis, A., Ochsman, R. B., Parrish, R. N., & Weeks, G. D. Studies in interactive communication: I. The effects of four communication modes on the behavior of teams during cooperative problem-solving. Human Factors, 1972, 14, 487-509.

Chapanis, A., & Overbey, C. M. Studies in interactive communication: III. Effects of similar and dissimilar communication channels and two interchange options on team problem solving. Perceptual and Motor Skills, 1974, 38, 343-374 (Monograph Supplement 2-V38).

Chapanis, A., Parrish, R. N., Ochsman, R. B., & Weeks, G. D. Studies in interactive communication: II. The effects of four communication modes on the linguistic performance of teams during cooperative problem solving. Human Factors, 1977, 19, 101-126.

Chapanis, A., & Williams, E. Human considerations in interactive telecommunications. In E. I. Salkovitz (Ed.) Science, technology, and the modern Navy. Arlington, Va.: Office of Naval Research, 1976.

Ford, W. R., Chapanis, A., & Weeks, G. D. Self-limited and unlimited word usage during problem solving in two telecommunication modes. Journal of Psycholinguistic Research, in press.

Kelly, M. J. Studies in interactive communication: Limited vocabulary natural language dialogue (Doctoral dissertation, The Johns Hopkins University, 1975). Dissertation Abstracts International, 1976, 36, 3647B. (University Microfilms No. 76-1518)

Kelly, M. J., & Chapanis, A. Limited vocabulary natural language dialogue. International Journal of Man-Machine Studies, 1977, 9, 479-501.

Krueger, G. P. Conferencing and teleconferencing in three communication modes as a function of the number of conferees. (Doctoral dissertation, The Johns Hopkins University, 1976). Dissertation Abstracts International, 1977, 37, 5400B. (University Microfilms No. 77-7741)

Michaelis, P. R., Chapanis, A., Weeks, G. D., & Kelly, M. J. Word usage in interactive dialog with restricted and unrestricted vocabularies. IEEE Transactions on Professional Communication, 1977, PC-20, 214-221.

Ochsman, R. B. The effects of ten communication modes on the behavior of teams during cooperative problem-solving. (Doctoral dissertation, The Johns Hopkins University, 1973). Dissertation Abstracts International, 1976, 36, 5767B. (University Microfilms No. 76-11, 215)

Ochsman, R. B., & Chapanis, A. The effects of 10 communication modes on the behavior of teams during co-operative problem-solving. International Journal of Man-Machine Studies, 1974, 6, 579-619.

Overbey, C. M. The effects of similar and dissimilar communication channels and two interchange conditions on team problem-solving. (Doctoral dissertation, The Johns Hopkins University, 1974). Dissertation Abstracts International, 1975, 35, 6139B. (University Microfilms No. 75-12,959)

Parrish, R. N. Interactive communication in team problem-solving as a function of two educational levels and two communication modes. (Doctoral dissertation, The Johns Hopkins University, 1973). Dissertation Abstracts International, 1974, 34, 5721B. (University Microfilms No. 74-10,440)

Stoll, F. C., Hoecker, D. G., Krueger, G. P., & Chapanis, A. The effects of four communication modes on the structure of language used during cooperative problem-solving. Journal of Psychology, 1976, 94, 13-26.

Weeks, G. D. Alternative telecommunication modes for conflictive and cooperative problem-solving. (Doctoral dissertation, The Johns Hopkins University, 1974). Dissertation Abstracts International, 1977, 38, 945B. (University Microfilm No. 77-16,566)

Weeks, G. D., & Chapanis, A. Cooperative versus conflictive problem-solving in three telecommunication modes. Perceptual and Motor Skills, 1976, 42, 879-917.

Weeks, G. D., Kelly, M. J., & Chapanis, A. Studies in interactive communication: V. Cooperative problem solving by skilled and unskilled typists in a teletypewriter mode. Journal of Applied Psychology, 1974, 59, 665-674.